Manufacturing & Prototyping

Bonded Invar Clip Removal Using Foil Heaters

Goddard Space Flight Center, Greenbelt, Maryland

A new process uses local heating and temperature monitoring to soften the adhesive under Invar clips enough that they can be removed without damaging the composite underneath or other nearby bonds. Two 1×1 in. (≈2.5×2.5 cm), 10-W/in.^{2} (≈1.6-W/cm^2), 80-ohm resistive foil Kapton foil heaters, with pressure-sensitive acrylic adhesive backing, are wired in parallel to a 50-V, 1-A limited power supply. At 1 A, 40 W are applied to the heater pair. The temperature is monitored in the clip radius and inside the tube, using a dual thermocouple readout. Several layers of aluminum foil are used to speed the heat up, allowing clips to be removed in less than five minutes. The very local heating via the foil heaters allows good access for clip removal and protects all underlying and adjacent materials.

This work was done by James T. Pontius and James G. Tuttle of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15770-1

Fabricating Radial Groove Gratings Using Projection Photolithography

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Projection photolithography has been used as a fabrication method for radial grove gratings. Use of photolithographic method for diffraction grating fabrication represents the most significant breakthrough in grating technology in the last 60 years, since the introduction of holographic written gratings. Unlike traditional methods utilized for grating fabrication, this method has the advantage of producing complex diffractive groove contours that can be designed at pixel-by-pixel level, with pixel size currently at the level of 45×45 nm. Typical placement accuracy of the grating pixels is 10 nm over 30 nm. It is far superior to holographic, mechanically ruled or direct e-beam written gratings and results in high spatial coherence and low spectral cross-talk. Due to the smooth surface produced by reactive ion etch, such gratings have a low level of randomly scattered light. Also, due to high fidelity and good surface roughness, this method is ideally suited for fabrication of radial groove gratings.

The projection mask is created using a laser writer. A single crystal silicon wafer is coated with photoresist, and then the projection mask, with its layer of photoresist, is exposed for patterning in a stepper or scanner. To develop the photoresist, the fabricator either removes the exposed areas (positive resist) of the unexposed areas (negative resist). Next, the patterned and developed photoresist silicon substrate is subjected to reactive ion etching. After this step, the substrate is cleaned. The projection mask is fabricated according to electronic design files that may be generated in GDS file format using any suitable CAD (computer-aided design) or other software program.

Radial groove gratings in off-axis grazing angle of incidence mount are of special interest for x-ray spectroscopy, as they allow achieving higher spectral resolution for the same grating area and have lower alignment tolerances than traditional in-plane grating scheme. This is especially critical for NASA Constellation-X project that will utilize hundreds of gratings all of which need to be precisely aligned for x-ray observation of space.

This work was done by Dmitri Iazikov and Thomas W. Mossberg of LightSmyth Technologies for Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15686-1

Gratings Fabricated on Flat Surfaces and Reproduced on Non-Flat Substrates

This technology has application as diffraction gratings in optical components.

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A method has been developed for fabricating gratings on flat substrates, and then reproducing the groove pattern on a curved (concave or convex) substrate and a corresponding grating device. First, surface relief diffraction grating grooves are formed on flat substrates. For example, they may be fabricated using photolithography and reactive ion etching, maskless lithography, holography, or mechanical ruling. Then, an imprint of the grating is made on a deformable substrate, such as plastic, polymer, or other materials using thermoforming, hot or cold embossing, or other methods. Interim stamps using electroforming, or other methods, may be produced for the imprinting process or if the same polarity of the grating image is required. The imprinted, deformable substrate is then attached to a curved, rigid substrate using epoxy or other suitable adhesives. The imprinted surface is facing away from the curved rigid substrate.

As an alternative fabrication method, after grating is imprinted on the deformable substrate as described above, the grating may be coated with thin conformal conductive layer (for example, using vacuum deposition of gold). Then the membrane may be mounted over an opening in a pressured vessel in a manner of a membrane on a drum, grating side out. The pressure inside of the vessel may be changed with respect to the ambient pressure to produce concave or convex membrane surface. The shape of the opening may control the type of the surface curvature (for example, a circular opening would create spherical surface, oval opening would create toroidal surface, etc.). After that, well-known electroforming methods may be used to create a replica of the grating on the concave or convex membrane. For example, the pressure vessel assembly may be submerged into an electro-forming solution and negative electric potential applied to the metal coated membrane using an insulated wire. Positive electric potential may be then applied to a nickel or other metal plate submerged into the same solution. Metal ions would transfer from the plate through the solution into the membrane, producing high fidelity metal replica of the grating on the membrane.

In one variation, an adhesive may be deposited on the deformable substrate, and then cured without touching the rigid, curved substrate. Edges of the deformable substrate may be attached to the rigid substrate to ensure uniform deformation of the deformable substrate. The assembly may be performed in vacuum, and then taken out to atmospheric pressure conditions to ensure that no air is trapped between the deformable and rigid substrates.

Alternatively, a rigid surface with complementary curvature to the rigid substrate may be used to ensure uniform adhesion of the deformable substrate to the rigid substrate. Liquid may be applied to the surface of the deformable substrate to uniformly distribute pressure across its surface during the curing or hardening of the adhesive, or the film may be pressed into the surface using a deformable object or surface. After the attachment is complete, the grooves may be coated with reflective or dielectric layers to improve diffraction efficiency.

This work was done by David Content of Goddard Space Flight Center and Dmitri Iazikov, Thomas W. Mossberg, and Christopher M. Greiner of LightSmyth Technologies. Further information is contained in a TSP (see page 1). GSC-15769-1